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SR Policy Extensions for energy efficiency
draft-liu-idr-sr-policy-energy-efficiency-00

Abstract

[draft-liu-spring-sr-energy-efficiency-00] describes the types of energy consumption information, how to collect energy consumption information, and the framework for path selection based on energy consumption information.

This document details the extensions to the BGP SR Policy and BGP-LS SR Policy to encapsulate the energy consumption information for each segment list of the SR Policy candidate paths, enabling its utilization in the route selection process.

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1. Introduction

The importance of energy efficiency in modern networks is increasingly evident. In addition to reducing the power consumption of devices, network technologies can be leveraged to redirect traffic towards energy-efficient devices and paths, effectively lowering the energy consumption of network communications.

[draft-liu-spring-sr-energy-efficiency-00] describes how energy-consumption information is utilized in SR networks. It elaborates on the use of energy consumption information for path computation in SR networks.

The metrics for energy consumption include:

Maximum Energy Consumption: The power consumption at full load, measured in watts.

Real-Time Energy Consumption: The real-time power consumption, measured in watts.

Maximum Unit Energy Consumption: The power consumption at full load divided by traffic, measured in watts per gigabyte (W/GB).

Real-Time Unit Energy Consumption: The real-time power consumption divided by real-time traffic, measured in watts per gigabyte (W/GB).

Average Unit Energy Consumption: The change in power consumption over a measurement period divided by the change in traffic, measured in watts per gigabyte (W/GB).

In scenarios utilizing SR Policy, after the SR Policy is installed on the ingress node, packets can be steered into the SR Policy through route selection. When multiple routes to the same destination exist, the route selection node may choose a route based on local policies, which could incorporate the energy consumption information of the selected path. Therefore, it is necessary to carry the energy consumption information for each segment list of the SR Policy candidate paths to facilitate route selection.

Within a domain, SR Policy routing information is disseminated using BGP UPDATE messages. When collecting SR Policy information using a controller, BGP-LS messages are typically employed, allowing devices to convey SR Policy information to the controller. When the controller distributes SR Policy to the ingress node, the PCEP protocol is generally used.

This document details the extensions to the BGP SR Policy and BGP-LS SR Policy to encapsulate the energy consumption information for each segment list of the SR Policy candidate paths, enabling its utilization in the route selection process.

1.1. Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

2. BGP SR Policy extension

[draft-ietf-idr-sr-policy-safi] defines how to convey SR Policy information via BGP<SR Policy SAFI NLRI>.

[draft-ietf-idr-sr-policy-metric-02] introduces a new Metric sub-TLV to carry Metric information for SR Policy candidate paths, which can include values for multiple Metric Types. We define energy consumption information as one of the Metric Types and assign it several energy-related Metric Type identifiers.

The SR Policy Encoding structure is as follows:

```
SR Policy SAFI NLRI: <Distinguisher, Policy-Color, Endpoint>

      Attributes:

      Tunnel Encaps Attribute (23)

              Tunnel Type: SR Policy

                 Binding SID

                 Preference

                 Priority

                 Policy Name

                 Policy Candidate Path Name

                 Explicit NULL Label Policy (ENLP)

                 Segment List

                     Weight

                     Metric

                     Segment

                     Segment

                     ....

                     ....
```

Where metric represents the measurement of the segment list and can include various types of metrics. This document introduces a new metric type to carry energy consumption-related measurement information.

Metric Type for Energy Consumption:

Type1: Maximum Energy Consumption

Type2: Real-Time Energy Consumption

Type3: Maximum Unit Energy Consumption

Type4: Real-Time Unit Energy Consumption

Type5: Average Unit Energy Consumption

3. BGP-LS SR Policy extension

[draft-ietf-idr-bgp-ls-sr-policy-10] describes how to carry SR Policy information via BGP-LS. The SR Segment List Metric sub-TLV reports the computed metric of the specific SID-List. The Metric Type can support various types of metrics, and by including energy consumption-related metrics, it enables the use of the SR Segment List Metric sub-TLV to advertise the energy consumption metric of the Segment List. Note that the metric types here refer to BGP-LS SR Policy Metric Types, not "IGP Metric."

Code Point	Metric Type	Reference
0	IGP	[RFC5305] Section 3
1	Min Unidirectional Delay	[RFC8570] Section 4.2
2	TE	[RFC5305] Section 3.7
3	Hop Count	[RFC5440] Section 7.8

4	SID List Length	[RFC8664] Section 4.5
5	Bandwidth	[I-D.ietf-lsr-flex-algo-bw-con]
6	Avg Unidirectional Delay	[RFC8570] Section 4.1
7	Unidirectional Delay Variation	[RFC8570] Section 4.3
8	Loss	[RFC8570] Section 4.4
TBD6	Maximum Energy Consumption(This Document)	
TBD7	Real-Time Energy Consumption(This Document)	
TBD8	Maximum Unit Energy Consumption(This Document)	
TBD9	Real-Time Unit Energy Consumption(This Document)	
TBD10	Average Unit Energy Consumption(This Document)	
128-255	User Defined [I-D.ietf-lsr-flex-algo-bw-con]	

[draft-ietf-idr-bgp-ls-sr-policy] The SR Candidate Path Constraints TLV is an optional TLV used to report constraints associated with a candidate path. By including the SR Metric Constraint Sub-TLV, it can specify metric constraints for the candidate path. By defining the metric type as energy consumption-related metrics, it enables the use of energy consumption metrics as constraints for the candidate path. Note that the metric types here also refer to BGP-LS SR Policy Metric Types.

4. Metric process of SR Policy segment list

[draft-ietf-idr-sr-policy-metric-02] describes how to handle various metrics of SR Policy Segment Lists (Seglists). When the local policy specifies the use of energy consumption-related metrics, these metrics are utilized for Seglist selection during path determination.

When the SR Policy headend node obtains the SR Policy segment list with the metric field, the metric can be of any defined type (e.g., IGP metric, minimum unidirectional link delay, TE metric, hop count, SID list length, maximum energy consumption per unit, real-time energy consumption per unit, etc.).

The rules for processing SR Policy metrics are as follows:

The type of metric to be used is determined by the local policy, which can be configured by the user. For example, the user may specify the real-time energy consumption per unit as the local policy.

The metric of the active candidate path is used as the metric of the SR Policy.

The metric of the active candidate path is determined by the maximum value of the specified metric type across all segment lists.

Example:

SR Policy: (Headend:1::1, Color: 2, EndPoint: 2::2)

Candidate path preference: 200

Segment list 1: (IGP metric: 20, Link delay: 10, TE metric: 10, Maximum Unit Energy Consumption: 20, Real-Time Unit Energy Consumption, 10)

Segment list 2: (IGP metric: 30, Link delay: 20, TE metric: 15, Maximum Unit Energy Consumption: 40, Real-Time Unit Energy Consumption, 30)

Candidate Path preference: 100

Segment list 1: (IGP metric: 40, Link delay: 20, TE metric: 20, Maximum Unit Energy Consumption: 20, Real-Time Unit Energy Consumption, 10)

Segment list 2: (IGP metric: 30, Link delay: 10, TE metric: 15, Maximum Unit Energy Consumption: 40, Real-Time Unit Energy Consumption, 30)

Local policy: Real-Time Unit Energy Consumption

Active candidate path: preference 200

Active candidate path metric: 10, which is the Real-Time Unit Energy Consumption of all segment lists in the candidate path.

5. Security Considerations

Procedures and protocol extensions defined in this document do not affect the BGP security model. See the "Security Considerations" section of [RFC4271] for a discussion of BGP security.

Security considerations for acquiring and distributing BGP-LS information are discussed in [RFC7752].

6. IANA Considerations

6.1. BGP Energy Consumption Metric Type

New metric types are requested from "Metric Type" under the "BGP Tunnel Encapsulation".

Code Point	Metric Type
0	IGP Metric
1	Min Unidirectional Link Delay [RFC7471]
2	TE Metric [RFC3630]
3	Hop Count (refer [RFC5440])
4	SID List Length
5	Loss Rate
TBD1	Maximum Energy Consumption(This Document)
TBD2	Real-Time Energy Consumption(This Document)
TBD3	Maximum Unit Energy Consumption(This Document)
TBD4	Real-Time Unit Energy Consumption(This Document)
TBD5	Average Unit Energy Consumption(This Document)
251-255	Private Use (not to be assigned by IANA)

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Figure 1: BGP Metric Type Code Point

6.2. BGP-LS Energy Consumption Metric Type

New metric types are requested from "BGP-LS Metric Type".

Code Point	Metric Type	Reference
0	IGP	[RFC5305] Section 3
1	Min Unidirectional Delay	[RFC8570] Section 4.2
2	TE	[RFC5305] Section 3.7
3	Hop Count	[RFC5440] Section 7.8
4	SID List Length	[RFC8664] Section 4.5
5	Bandwidth	[I-D.ietf-lsr-flex-algo-bw-con]
6	Avg Unidirectional Delay	[RFC8570] Section 4.1
7	Unidirectional Delay Variation	[RFC8570] Section 4.3
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TBD6	Maximum Energy Consumption	(This Document)
TBD7	Real-Time Energy Consumption	(This Document)
TBD8	Maximum Unit Energy Consumption	(This Document)
TBD9	Real-Time Unit Energy Consumption	(This Document)

|TBD10 | Average Unit Energy Consumption(This Document)|

|128-255| User Defined | [I-D.ietf-lsr-flex-algo-bw-con] |

Figure 2: BGP-LS Metric Type Code Point

7. References

7.1. Normative References

[draft-liu-spring-sr-energy-consumption-00] lin, New H3C Technologies, "Computing Energy Consumption Path in Segment Routing Networks", draft-liu-spring-sr-energy-consumption-00, DOI 10.17487/draft-lin-spring-sr-for-green-metric-00, Febauary 2025, <https://www.rfc-editor.org/info/DOI 10.17487/draft-liu-spring-sr-energy-consumption-00>.

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[I-D.draft-ietf-idr-sr-policy-metric-02] K. Zhang, J. Dong, Huawei, K. Talaulikar, Cisco Systems, "BGP SR Policy Extensions for metric", Work in Progress, Internet-Draft, draft-ietf-idr-sr-policy-metric-02, December 2024, <https://datatracker.ietf.org/doc/html/draft-ietf-idr-sr-policy-metric-02>.

7.2. Informational References

TBD

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